GRADE 12
DIPLOMA EXAMINATION

Chemistry 30

January 1991

Alberta

EDUCATION

GRADE 12 DIPLOMA EXAMINATION
CHEMISTRY 30

DESCRIPTION

Time: 2½ hours

Total possible marks: 70

This is a **closed-book** examination consisting of **three** parts:

    PART A has 49 multiple-choice questions each with a value of one mark.

    PART B has seven numerical-response questions each with a value of one mark.

    PART C has three written-response questions for a total of 14 marks.

A chemistry data booklet is provided for your reference.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work. **No marks** will be given for work done on the tear-out pages.

GENERAL INSTRUCTIONS

Fill in the information required on the answer sheet and the examination booklet as directed by the examiner.

You are expected to provide your own calculator.

Carefully read the instructions for each part before proceeding.

DO NOT FOLD EITHER THE ANSWER SHEET OR THE EXAMINATION BOOKLET.

The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
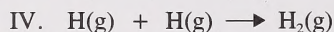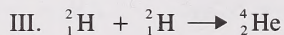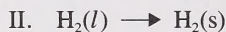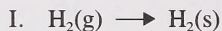
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PART A

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iv

1. A sample of water is heated and its temperature changes from 22°C to 56°C. This change is due to an increase in

   A. kinetic energy
   B. potential energy
   C. potential energy and a decrease in kinetic energy
   D. kinetic energy and a decrease in potential energy

2. Which statement describes the energy conditions when a liquid substance changes to a gas at the same temperature?

   A. The potential energy increases and the kinetic energy remains the same.
   B. The potential energy remains the same and the kinetic energy increases.
   C. The potential energy increases and the kinetic energy increases.
   D. The potential energy decreases and the kinetic energy decreases.

3. Which of the following represents a molar heat of formation?

   A. $H_2O(l) \longrightarrow H_2O(g)$ $\quad\quad\quad\quad \Delta H = +40.8$ kJ/mol

   B. $CO_2(g) \longrightarrow C(s) + O_2(g)$ $\quad\quad \Delta H = +393.5$ kJ/mol

   C. $5C(s) + 6H_2(g) \longrightarrow C_5H_{12}(l)$ $\quad \Delta H = +146.4$ kJ/mol

   D. $\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \longrightarrow NO(g)$ $\quad \Delta H = +90.2$ kJ/mol

4. The standard heat of formation of a substance would change if the substance had

   A. stronger bonds between atoms
   B. decreased kinetic energy
   C. increased kinetic energy
   D. a lower specific heat

5. Which reaction requires energy to occur?

   A. $2Al(s) + \frac{3}{2}O_2(g) \longrightarrow Al_2O_3(s) + 1675.7$ kJ

   B. $Sn(s) + Cl_2(g) \longrightarrow 325.1$ kJ $+ SnCl_2(s)$

   C. $SO_3(g) \longrightarrow SO_2(g) + \frac{1}{2}O_2(g)$ $\quad\quad \Delta H = +98.9$ kJ

   D. $2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$ $\quad\quad \Delta H = -285.8$ kJ

6. What information is conveyed by the equation $H_2(g) + 432 \text{ kJ} \longrightarrow 2H(g)$?

   A. The reaction is exothermic.
   B. The ΔH of the reaction is negative.
   C. The enthalpy of $2H(g)$ is lower than the enthalpy of $H_2(g)$.
   D. The equation represents the energy required to break the bond between hydrogen atoms in one mole of hydrogen.

7. For a substance, a chemical change involves more energy than a phase change does because chemical bonds are

   A. stronger than the forces between molecules
   B. weaker than the forces between molecules
   C. stronger than the nuclear forces
   D. weaker than the nuclear forces

Use the following information to answer question 8.

These equations represent exothermic changes:

$$\text{I.} \quad H_2(g) \longrightarrow H_2(s)$$

$$\text{II.} \quad H_2(l) \longrightarrow H_2(s)$$

$$\text{III.} \quad {}^2_1H + {}^2_1H \longrightarrow {}^4_2He$$

$$\text{IV.} \quad H(g) + H(g) \longrightarrow H_2(g)$$

8. When the equations are arranged according to increasing molar heats of reaction, the order is

   A. I, II, IV, III
   B. II, I, III, IV
   C. II, I, IV, III
   D. IV, II, III, I

9. For the combustion of methanol, $CH_3OH(l) + \frac{3}{2}O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$, which is a component of gasohol, the molar heat of combustion is

   A. -148.9 kJ/mol
   B. -638.1 kJ/mol
   C. -874.3 kJ/mol
   D. -1116.1 kJ/mol

- 2 -

Use the following diagram to answer question 10.

A + B

ΔE_p (kJ)

AB

Reaction Co-ordinate
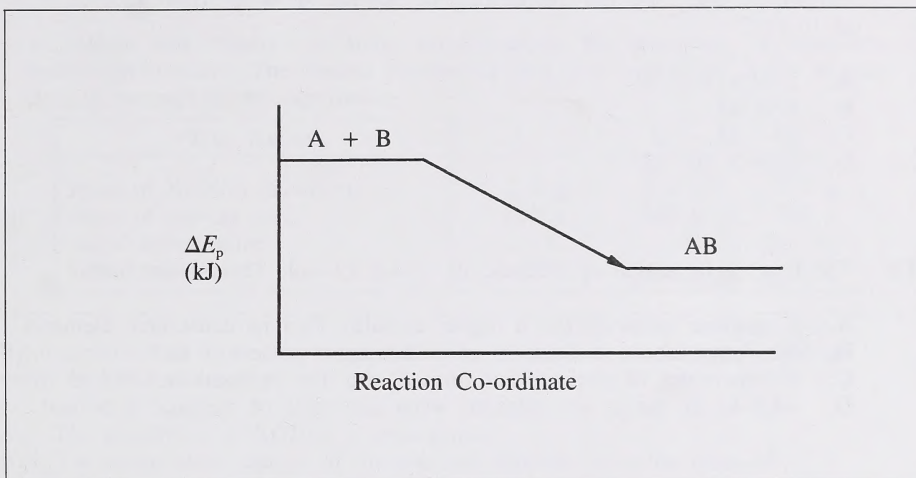
10. If AB represents the product of a chemical reaction, the reaction is one in which

A. E_p increases
B. energy is released
C. heat is absorbed
D. ΔH is positive

Use the following information to answer question 11.

A student was asked to determine the specific heat capacity of an unknown metal. The student placed the metal sample in a calorimeter containing water and subsequently collected the following data:

mass of metal sample	75.24 g
mass of water in calorimeter	101.65 g
initial temperature of calorimeter water	22.5°C
final temperature of the whole system	25.6°C

11. In order to determine the specific heat capacity of the metal, the student also needs to know the

A. density of the metal sample
B. volume of the calorimeter water
C. final temperature of the metal sample
D. initial temperature of the metal sample

12. How much heat is produced when 3.43 g of silver iodide react in a bomb calorimeter and raise the temperature of 500 mL of water from 13.2°C to 16.1°C?

   A. 2.59×10^{-3} kJ
   B. 6.08 kJ
   C. 33.7 kJ
   D. 6.08×10^3 kJ

13. The heat of formation of methane is -74.8 kJ/mol. This means that

   A. a methane molecule has a higher enthalpy than its constituent elements
   B. the formation of methane is an endothermic process
   C. if two moles of methane are formed, the heat released is 149.6 kJ
   D. 74.8 kJ of energy are released when one mole of methane is burned

Use the following reaction to answer question 14.

$$Li(s) + \tfrac{1}{2}H_2(g) \longrightarrow LiH(s) + 90.5 \text{ kJ}$$
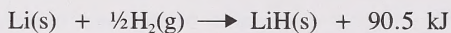
14. The amount of heat necessary to decompose 15.9 g of LiH(s) into Li(s) and $H_2(g)$ at standard conditions is

   A. 15.9 kJ
   B. 90.5 kJ
   C. 181 kJ
   D. 1.44 MJ

A student was required to study experimentally the dissolving of potassium hydroxide in water. The student prepared a data table and filled in the missing data at the end of the experiment.

Trial Number	1	2	3
mass of KOH(s) dissolved	2.5 g	5.0 g	7.5 g
mass of solvent used	200 g	200 g	200 g
initial temperature	____°C	____°C	____°C
final temperature	____°C	____°C	____°C

15. By using the data from the completed table, the student would **not** be able to verify which statement?

    A.   The dissolving of KOH(s) is exothermic.
    B.   The temperature change of the solution depends upon the mass of KOH(s) used.
    C.   The amount of heat gained by the solvent is affected by the concentration of KOH(aq).
    D.   The mass of solvent used affects dissolving time.

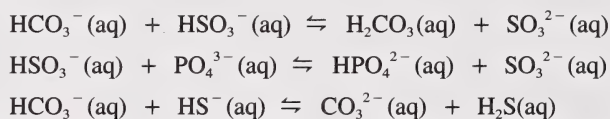A student tested a solution and recorded these observations:

    I. pH = 2.6
   II. tasted bitter
  III. turned blue litmus paper red
  IV. conducted electricity

16. The observation that is likely incorrect is numbered

    A.   I
    B.   II
    C.   III
    D.   IV

17. A neutralization reaction is a reaction between

    A.   an acid and a base to produce a salt and water
    B.   an acid and a metal to produce a salt and hydrogen gas
    C.   two aqueous solutions in which a precipitate is produced
    D.   an oxidizing agent and a reducing agent in which a metal is produced

18. Milk of magnesia tastes bitter and turns red litmus paper blue. It is reasonable to conclude that the milk of magnesia could

A. neutralize a solution of HCl(aq)
B. neutralize a solution of NH_3(aq)
C. raise the $[H_3O^+$(aq)$]$
D. lower the pH of an aqueous solution

19. Which of these substances is an Arrhenius acid?

A. $C_2H_5OH(l)$
B. CH_4(g)
C. HBr(g)
D. KOH(s)

20. In the reaction HSO_3^-(aq) + NH_3(aq) $\leftrightharpoons$ NH_4^+(aq) + SO_3^{2-}(aq), both

A. HSO_3^-(aq) and SO_3^{2-}(aq) act as acids

B. HSO_3^-(aq) and NH_4^+(aq) act as acids

C. HSO_3^-(aq) and NH_4^+(aq) act as bases

D. NH_3(aq) and NH_4^+(aq) act as bases

Use the following reactions to answer question 21.

HCO_3^-(aq) + HSO_3^-(aq) $\leftrightharpoons$ H_2CO_3(aq) + SO_3^{2-}(aq)
HSO_3^-(aq) + PO_4^{3-}(aq) $\leftrightharpoons$ HPO_4^{2-}(aq) + SO_3^{2-}(aq)
HCO_3^-(aq) + HS^-(aq) $\leftrightharpoons$ CO_3^{2-}(aq) + H_2S(aq)

21. Identify the substance that behaves as **both** an acid and a base.

A. HCO_3^-(aq)

B. HSO_3^-(aq)

C. HS^-(aq)

D. HPO_4^{2-}(aq)

22. When used to describe an acid, the word "weak" means that the acid

    A. has a low pH
    B. has a low concentration
    C. shows incomplete dissociation
    D. is monoprotic

23. When an acid is progressively added to a solution of a base, what change in the initial pH of the solution can be observed?

    A. An increase in pH from 9 to 12
    B. An increase in pH from 3 to 8
    C. A decrease in pH from 7 to 6
    D. A decrease in pH from 9 to 5

24. A barium hydroxide solution of 1.0×10^{-2} mol/L concentration has a pH of

    A. 2.00
    B. 12.00
    C. 12.30
    D. 13.70

Use the following information to answer question 25.

A student who wanted to determine the pH of an unknown solution recorded these observations:

Indicator	Color of the Indicator in the Solution
methyl orange	yellow
methyl red	yellow
bromothymol blue	blue
phenolphthalein	colorless

25. The pH of the solution is most likely

    A. 9.0
    B. 8.0
    C. 7.0
    D. 6.0

26. The net ionic equation that best describes the reaction that occurs between aqueous solutions of lithium hydroxide and methyl orange is

   A. $OH^-(aq) + HMo(aq) \leftrightarrows H_2O(l) + Mo^-(aq)$

   B. $LiOH(aq) + HMo(aq) \leftrightarrows LiMo(aq) + H_2O(l)$

   C. $HMo(aq) + H_2O(l) + OH^-(aq) \leftrightarrows 2H_2O(l) + Mo^-(aq)$

   D. $Li^+(aq) + H_2O(l) + OH^-(aq) + HMo(aq) \leftrightarrows 2H_2O(l) + Mo^-(aq) + Li^+(aq)$

27. The reaction $HB(aq) + X^-(aq) \leftrightarrows HX(aq) + B^-(aq)$ will favor products if

   A. $[X^-(aq)]$ is greater than $[B^-(aq)]$ at equilibrium
   B. $[HX(aq)]$ is less than $[HB(aq)]$ at equilibrium
   C. $B^-(aq)$ is a stronger base than $X^-(aq)$
   D. $HB(aq)$ is a stronger acid than $HX(aq)$

28. When added to $H_3PO_4(aq)$, which base would cause a reaction that favors the reactants?

   A. $OH^-(aq)$

   B. $OCl^-(aq)$

   C. $NO_2^-(aq)$

   D. $SO_4^{2-}(aq)$

29. A student suspects that an unknown acid of known concentration is diprotic. In order to test this hypothesis, the most useful procedure for the student to follow would be to

   A.   determine the molar mass
   B.   find the pH by using an indicator
   C.   titrate with a known concentration of $NaOH(aq)$
   D.   establish the degree of electrical conductivity

40 mL of H_3PO_4(aq) were titrated with KOH(aq). The graph represents this titration:

pH

II

I

volume of base
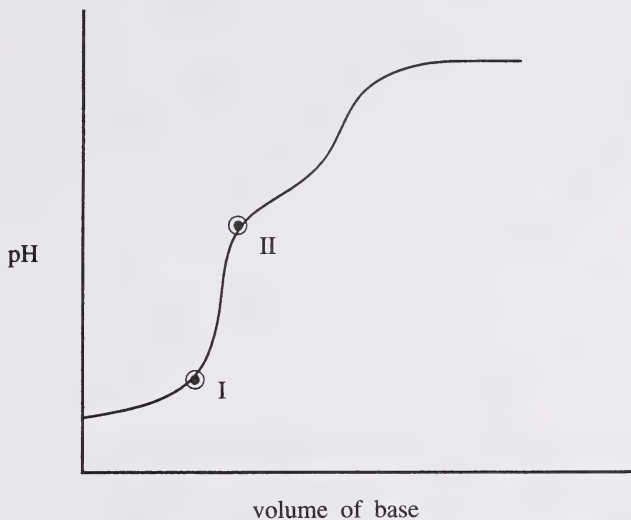
30. The graph segment from I to II represents that part of the reaction where

A. H_3O^+(aq) unites with OH^-(aq) to form $H_2O(l)$
B. H_3PO_4(aq) has been converted to $H_2PO_4^-$(aq)
C. no ionizable protons remain
D. only HPO_4^{2-}(aq) remains

31. 200 mL of 0.125 mol/L solution of potassium hydroxide were added to 100 mL of 0.100 mol/L solution of nitric acid. Which indicator is coupled with the effect it would produce in the new solution?

A. Orange IV — the solution is orange
B. Thymol blue — the solution is orange
C. Indigo carmine — the solution is green
D. Phenolphthalein — the solution is colorless

The graph shows the change in pH as a function of the volume of hydrochloric acid of unknown concentration added to 40 mL of 0.03 mol/L sodium hydroxide solution.
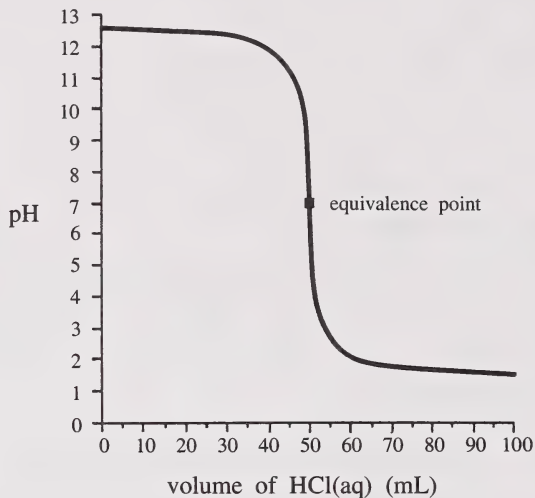
32. The initial pH of the acid is

    A.   7.0
    B.   1.6
    C.   1.5
    D.   1.0
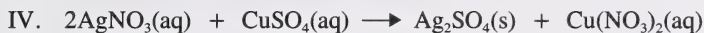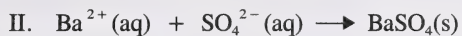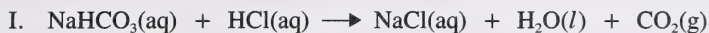
33. Reducing agents are

    A.   usually positively charged
    B.   able to react with Li(s)
    C.   able to lose electrons
    D.   easily reduced

34. Which incomplete half-reaction is an oxidation?

    A. $2H^+(aq) + \frac{1}{2}O_2(g) \longrightarrow H_2O(l)$

    B. $Cr_2O_7^{2-}(aq) + 14H^+(aq) \longrightarrow 2Cr^{3+}(aq) + 7H_2O(l)$

    C. $K^+(aq) \longrightarrow K(s)$

    D. $2I^-(aq) \longrightarrow I_2(s)$

I. $NaHCO_3(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l) + CO_2(g)$

II. $Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s)$

III. $2Fe^{3+}(aq) + Sn(s) \longrightarrow 2Fe^{2+}(aq) + Sn^{2+}(aq)$

IV. $2AgNO_3(aq) + CuSO_4(aq) \longrightarrow Ag_2SO_4(s) + Cu(NO_3)_2(aq)$

35. The redox reaction is numbered

A. I
B. II
C. III
D. IV

$ClO_3^-(aq) + 6H^+(aq) + 5e^- \longrightarrow \frac{1}{2}Cl_2(g) + 3H_2O(l)$ $E^\circ = 1.47$ V

$Cl_2(g) + 2e^- \longrightarrow 2Cl^-(aq)$ $E^\circ = 1.36$ V
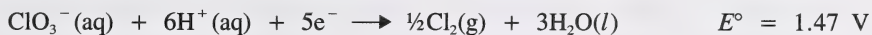
36. A student mixes acidified solutions of KCl(aq) and $KClO_3$(aq). Which observation is **not** correct?

A. Chlorine gas is produced.
B. A spontaneous reaction occurs.
C. The pH of the mixture decreases.
D. The concentrations of both ClO_3^-(aq) and Cl^-(aq) decrease.

37. In the molecules HClO, $HClO_2$, and $HClO_3$, the oxidation number for each chlorine is, respectively,

A. $+1, +3, +5$
B. $+1, +1, +1$
C. $-1, -3, -5$
D. $-1, -1, -1$

38. When an acid is added to a solution containing chromate ions, the reaction that occurs is $2CrO_4^{2-}(aq) + 2H^+(aq) \leftrightharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$. The change in oxidation number for chromium is

A. 0
B. 1
C. 2
D. 3

39. A student was asked to titrate an acidified $Fe^{2+}(aq)$ with $Na_2Cr_2O_7(aq)$. Assuming that all species are aqueous, what is the balanced net ionic equation for the reaction that occurs?

A. $6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \longrightarrow 2Cr^{3+} + 6Fe^{3+} + 14OH^-$

B. $6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \longrightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

C. $6Fe^{2+} + 2Na^+ + Cr_2O_7^{2-} + 14H^+ \longrightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

D. $6Fe^{2+} + 2Na^+ + Cr_2O_7^{2-} + 7H_2O \longrightarrow 2Cr^{3+} + 2Na^+ + 14OH^-$

40. A true statement that can be made from a reading of the standard electrode potentials table is that

A. silver bromide gains electrons more readily than hydrogen ions do
B. hydrogen ions gain electrons more readily than silver bromide does
C. hydrogen gas loses electrons more readily than cadmium metal does
D. hydrogen gas gains electrons more readily than silver bromide does

41. Reduction potentials are a measure of the tendency of

A. $H^+(aq)$ to gain electrons
B. a reducing agent to gain electrons
C. an oxidizing agent to lose electrons
D. an oxidizing agent to gain electrons

42. Which statement is true of a substance with an oxidation potential of 2.52 V?

A. It is a strong reducing agent.
B. It is a weak reducing agent.
C. It is a strong oxidizing agent.
D. It has a high electronegativity value.

43. Which reducing agent is the strongest?

    A. Fe(s)

    B. Cd^{2+}(aq)

    C. F^-(aq)

    D. I_2(s)

Use the following diagram to answer question 44.
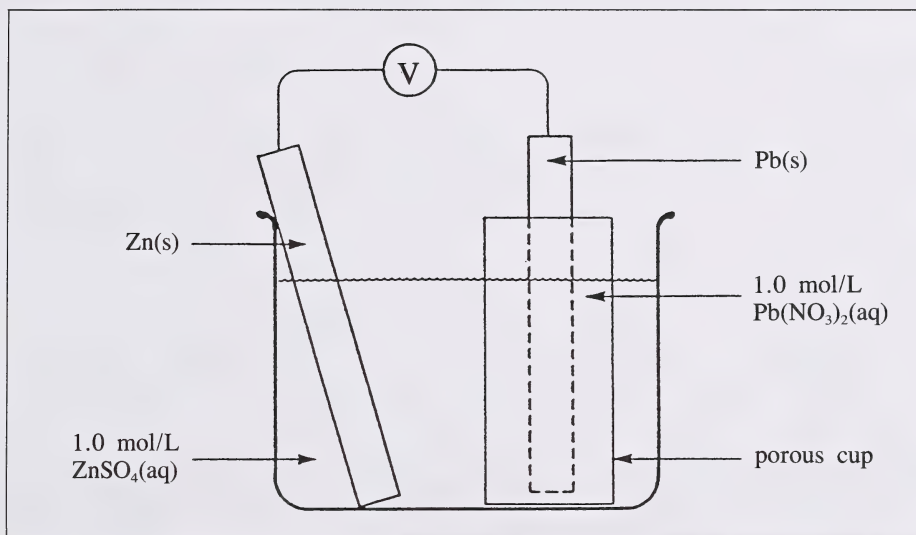
44. The voltage generated by this cell is

    A. +0.40 V
    B. +0.63 V
   **C.** +0.76 V
    D. +0.89 V

45. If fluorine gas is bubbled through NaI(aq),

    A. Na^+(aq) is reduced

    B. I^-(aq) is oxidized

    C. F_2(aq) is oxidized

    D. I^-(aq) is reduced

46. In an electrochemical cell, the cathode is the electrode at which electrons

    A. leave the half cell and oxidation takes place
    B. leave the half cell and reduction takes place
    C. enter the half cell and oxidation takes place
    D. enter the half cell and reduction takes place

47. In this cell, which lettered arrow indicates the movement of cations?
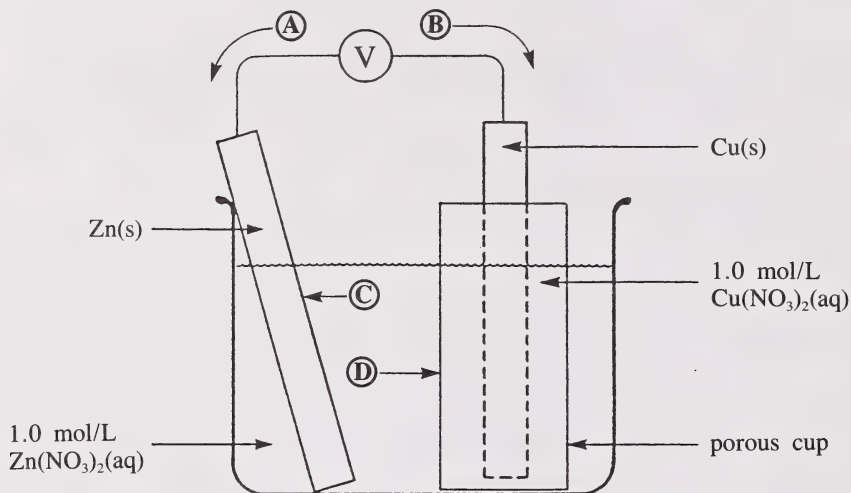
48. Silver plating of ornaments or utensils is done by electrolysis of a soluble silver compound. The object to be plated is placed at one of the electrodes. If 10.8 g of silver are to be deposited, how long will it take to plate the object using an electron flow of 0.500 A?

    A. 10.7 h
    B. 5.37 h
    C. 2.68 h
    D. 1.34 h

49. The time required to produce 10.0 g of chromium metal from a 0.10 mol/L solution of chromium(III) nitrate in an electrolytic cell is dependent upon the

    A. area of the anode in the cell
    B. initial mass of the cathode in the cell
    C. flow of electrons in amperes supplied to the cell
    D. charge of the nitrate ions in the solution

YOU HAVE NOW COMPLETED PART A. PROCEED DIRECTLY TO PART B.

PART B

INSTRUCTIONS

In this part of the examination, there are seven numerical-response questions each with a value of one mark. All numbers used in the questions are to be considered as the result of a measurement. Read each question carefully and answer each question.

Use the answer sheet provided.

For calculation questions, record your answer to **three** digits by writing it in the boxes and filling in the corresponding circles. Note: Fill in only **three** of the four boxes and circles; the decimal point on the answer sheet determines which three boxes and circles you should use.

Sample Calculation Question and Solution

The mass in grams of silver produced when 0.0220 mol of silver nitrate reacts with excess copper is _____ g. (Give your answer to three digits.)

$$\text{mass}_{Ag} = 0.0220 \text{ mol} \times 107.87 \text{ g/mol}$$
$$= 2.37314 \text{ g}$$
$$= 2.37 \text{ g (rounded to three digits)}$$

Record 2.37

Answer Sheet

2	3	7	

For correct-order questions, record your answer by writing it in the boxes and filling in the corresponding circles. Note: Fill in all **four** boxes and circles.

Sample Correct-order Question and Solution

When the following subjects are arranged in alphabetical order, the order will be __ , __ , __ , __ .

1. Mathematics
2. Chemistry
3. Biology
4. Physics

Answer 3, 2, 1, 4

Record 32.14

Use an HB pencil only.

Answer Sheet

3	2	1	4

If you wish to change an answer, erase **all** traces of your first answer.

START PART B IMMEDIATELY.

1. The ΔH for the reaction $NO_2(g) \longrightarrow NO(g) + \frac{1}{2}O_2(g)$ in kilojoules is $+$ _____ kJ. (Give your answer to three digits.)

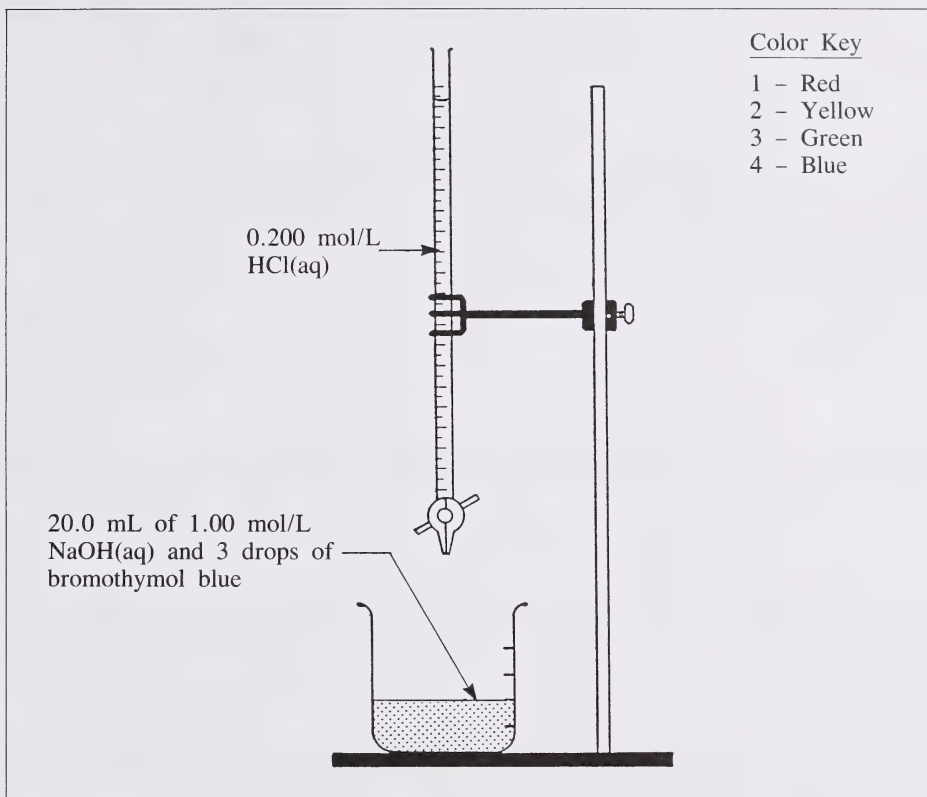**Use the following information to answer question 2.**

Some Experimental Steps

1. Record mass of thermometer using a balance.
2. Record room temperature using a thermometer.
3. Record volume of calorimeter water using a graduated cylinder.
4. Record lowest temperature reached in calorimeter.
5. Record mass of calorimeter using a balance.
6. Record highest temperature reached in calorimeter.
7. Record temperature of calorimeter water just after the addition of ice.
8. Record final volume of calorimeter contents using a graduated cylinder.
9. Record temperature of calorimeter water before the addition of ice.

2. A student wishes to determine the experimental heat of fusion of water using a foam calorimeter. The sequence of the four steps required to accomplish this is
_____ , _____ , _____ , _____ .

3. A solution of pH 9.35 has its hydronium ion concentration increased by a factor of 100. Its new pH is _____ . (Give your answer to three digits.)

4. The color of the solution in the beaker with

• no addition of HCl(aq) is _____ (Record in first column)

• 5.0 mL of HCl(aq) is _____ (Record in second column)

• 10.0 mL of HCl(aq) is _____ (Record in third column)

• 20.0 mL of HCl(aq) is _____ (Record in fourth column)

1. $HNO_2(aq)$	3. $H_3PO_4(aq)$
2. $H_2SO_4(aq)$	4. $H_2S(aq)$

5. The order of these 0.10 mol/L solutions from best to poorest electrical conductor is
—— , —— , —— , —— .

$$MgSO_4(s) + 4Zn(s) \longrightarrow ZnS(s) + MgO(s) + 3ZnO(s)$$

6. The molar heat of reaction for the reducing agent in joules per mole is
$-$_____ $\times 10^5$ J/mol. (Give your answer to three digits.)

1. $Cr(s)$	3. $Sn^{2+}(aq)$
2. $H_2O(l)$	4. $Fe^{2+}(aq)$

7. The order of these reducing agents from strongest to weakest
is —— , —— , —— , —— .

YOU HAVE NOW COMPLETED PART B. PROCEED DIRECTLY TO PART C.

PART C

1. 1.00 g of an element X(s) reacts completely with sufficient oxygen to produce 7.17×10^{-3} mol of a compound that has a formula $X_2O_3(s)$. All the energy released by this reaction raises the temperature of 100 g of water from 15.0°C to 33.5°C.

   a. Write a balanced chemical equation representing this reaction.

   b. Calculate the molar heat of formation ($\Delta H°_f$) for the compound $X_2O_3(s)$.

   c. A student correctly identifies the unknown element as gallium. What method was most likely used by the student to reach this conclusion?

2. a. For an acid-base titration, describe an experimental procedure that can be used to obtain the

   i) endpoint of the titration

   ii) equivalence point of the titration

b. Distinguish between the terms endpoint and equivalence point.

3. A sample of a salt containing Fe^{2+} was dissolved in 50.0 mL of a dilute acid solution and titrated with 0.100 mol/L $Cr_2O_7^{2-}$ (aq). The Fe^{2+} (aq) was oxidized to Fe^{3+} (aq) by 40.0 mL of the $Cr_2O_7^{2-}$ (aq) solution. Use half-reactions to write the balanced equation for the reaction and determine the mass of iron in the original salt.

YOU HAVE NOW COMPLETED THE EXAMINATION. IF YOU HAVE TIME, YOU MAY WISH TO GO BACK AND CHECK YOUR ANSWERS.

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